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DRYING OF TREE FRUITS WITH PARTICULAR REFERENCE TO DEHYDRATION AND PRE-TREATMENT WITH SULPHUR DIOXIDE

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DRYING OF TREE FRUITS WITH PARTICULAR REFERENCE TO DEHYDRATION AND PRE-TREATMENT WITH SULPHUR DIOXIDE

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1. Tree fruits dried in Australia. Prunes and apricots account for roughly 75% of the production, the remainder, in order of importance, consisting of free-stone peaches, apples, pears, nectarines and figs. Of the total of 5000-7000 tons per annum about 25% is exported. Though small, the industry is prosperous and well organized. Technical problems are investigated through a Dried Fruits Processing committee, the members of which have appropriate qualifications.

2. Sun drying. Most of the fruits, other than apples and plums, are sun dried, at low capital cost, by the grower. The main areas are the irrigations settlements of the Murray, Murrumbidgee and Goulburn rivers in southern Australia, where, during the drying season from December to February, relative humidity is usually low and shade temperatures may reach 100°F or more.

3. Dehydration. A steadily increasing proportion of the tree fruits is now being dehydrated. Nearly all prunes are dehydrated in specially constructed tunnels operated either by individual growers or co-operative bodies of growers. In Tasmania apples are dried in through-draught kilns with slatted wooden floors, heat being supplied to deep beds of sliced fruit mainly by convection from a furnace operated below floor level.

ECONOMICS OF DRYING

4. One of the main reasons for preserving fruit is to reduce wastage, which may be especially great in hot climates. The processed fruit must be in a form capable of easy storage for relatively long periods, and be of a quality acceptable to the consumer.

5. Freezing can only be practised in countries possessing appropriate facilities for processing, storage in bulk, transport, retailing and storage in the home; it will not be considered in any cost comparisons in this paper. Because of its present high cost freeze drying also will be disregarded.

6. Since prunes, nectarines and figs are not usually canned in Australia, the comparison of sun drying, dehydration, and canning which follows is confined to apricots and peaches. White,[2] in studying relative costs in 1950, found the cost of dehydrating

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2 White, L., Dehydration of tree fruits, Quart. Review Ag. Econ., 3, 20 (1950).

fruits to be half that of canning and the cost of sun drying to be about a quarter less than dehydration. An advantage of drying over canning is that practically all the fruit grown can be utilized.

7. The capital cost of establishing even a small cannery is, of course, high, and maintenance and operating costs are considerable. The capital costs of sun drying are low and within the means of the grower who can often use family labour for processing. While large dehydration plants are expensive, many small units suitable for operation by individual growers are relatively inexpensive.

RAW FRUIT FACTORS AFFECTING QUALITY

8. Variety. Fresh fruits with a high solids content usually have good flavour and also give a high yield of dried product. The varieties preferred for drying in Australia are: Prunes - D'Agen, Robe de Sergeant; Apples - Sturmer, Granny Smith; Apricots - Moorpark, Trevatt; Peaches - Elberta, J.H.Hale; Nectarines - Goldmine; Pears - William Bon Chrétien; Figs - Smyrna.

9. Maturity. For successful drying the fruit should be well matured. Apricots, peaches and nectarines picked at eating ripeness have when dried a more pronounced flavour than the canned product, the fruit for which is processed at a less mature stage. Prunes and figs are usually left on the tree until signs of desiccation become apparent. With pears it is practice to pick while still green and to ripen them fully off the tree before drying. Though somewhat wasteful of labour, the selective picking of stone fruits is usually justified by the improved quality of the dried product.

10. Size. To obtain uniform drying it is desirable to select large and small sized fruits from the bulk for separate handling.

11. Skin Type. Although the skin of fruits acts as a barrier to the uptake of preservatives before, and to the evaporation of water during, drying, only with apples is the skin invariably removed prior to drying .

PREPARATION FOR DRYING

12. Picking. Fruit, especially apricots, peaches, nectarines and pears, must not be dropped into picking containers but be handled carefully in that and all other operations, since being fully ripe, it will bruise easily. Bruising causes a discoloration, due to enzymic action, which once formed cannot be removed from the injured tissue.

13. Peeling. Because of their thick and waxy skin, apples should be peeled prior to drying. Machines to peel and core apples are available, ranging in size from small hand operated types to those of large capacity operated mechanically. Apricots, nectarines, prunes and figs are not usually peeled, but prunes are sometimes dipped into, or sprayed with, a weak solution of alkali which removes some of the waxy constituents and produces small cracks in the skins, so facilitating drying. Although not normally followed in commercial practice, the skinning of peaches and pears prior to drying has been shown by experiments[3] to result in an improved product. When fully

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[3] McBean, D., and Shipton, J., The dehydration of apricots and peaches, Commonwealth Scientific and Industrial Research Organization, Food Pres. Quart., 10, 59 (1950).

ripe these fruits can be peeled very readily by immersion in boiling water, or by steaming, for 30-45 seconds.

14. Sub-Division. Drying times are dependent upon the size of fruit or of pieces. In Australia, except for prunes, it is usual to dry stone fruits in halves after removing the pit. With prunes and figs, which are dried whole, the drying is slow. Pears are halved and the calyx is removed. Apples, after peeling and coring, are sliced into rings about 5-6 mm thick. Freestone peaches have been dehydrated experimentally as peeled slices but while the product is of excellent quality the slices are fragile when dry and stick to the trays.

15. Tray-type and Loading Rate. Since metal tends to corrode easily, trays used for fruit drying are made usually of wood, soft being preferred to hard woods which stain the product. Cleats are used to allow the trays to be stacked on 3 inch centres. The base of the tray on which the fruit is placed may be of slatted or continuous construction, the former allowing slightly faster drying. The floors of apple drying kilns are made of wooden slats. Loading rates range usually from 2 lb per square foot for apricots up to 4 lb per square foot for pears.

16. Blanching. Blanching of fruit in steam or hot water prior to dehydration has been recommended by Perry et al[4] to remove air from its tissues and to give a more translucent product. Australian experience[3] has not shown blanching to be advantageous and unblanched fruit has given produce of good quality and appearance, especially when reconstituted and cooked.

TREATMENT WITH SULPHUR DIOXIDE

17. Use of sulphur dioxide is desirable with all fruits except the naturally dark coloured prunes. Sulphur dioxide retards the browning reaction between amino acids and reducing sugars. The mechanism by which this occurs is not fully understood and is being investigated. The use of sulphur dioxide, permitted in most countries of the world with dried fruits, is limited in Australia to 3,000 parts per million. Since many factors affect the initial uptake of sulphur dioxide as well as its retention during drying, it is difficult, in commercial practice, to control its level in the dried fruit.

18. Methods.
(a) When drying vegetables, it is usual to dip the prepared pieces momentarily in a solution of sodium sulphite. If this method is adopted with fruits, using bisulphite or metabisulphite whose pH is nearer to that of fruits, an objectionable off-flavour develops in the dried product.
(b) Liquid sulphur dioxide may be used but its cost is considerably greater and may be prohibitive. Nowadays in Australia, the common practice, cheap and easy, is to place a plastic tent over a stack of loaded trays and to diffuse sulphur dioxide through them by burning sulphur in a small pit connected to the enclosure by an underground channel. Small holes in the top of the tent ensure even diffusion of the gas. More permanent structures of brick or concrete are little used.

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[4] Perry, R.L., Mrak, E.M., Phaff, H.J., Marsh, G.L., and Fisher, C.D., Fruit dehydration 1. Principles and equipment, Cal. Ag. Exp. St. Bull. No.698 (1946).

FACTORS AFFECTING UPTAKE OF SULPHUR DIOXIDE

19. Raw Fruit Characteristics. The cut surfaces of fruits of different types absorb sulphur dioxide at a similar rate, which is usually 6-7 times greater than through the skin. The fact that over-ripe fruit absorbs slightly less than ripe fruit is due probably to ripeness causing leakage of liquid into the intercellular spaces. This may also explain why blanched tissue tends to absorb less sulphur dioxide than unblanched. Small fruits absorb more than large ones because of their greater surface area to weight ratio.

20. Gas Concentration. The concentration of sulphur dioxide to which the fruit is exposed is one of the most important factors governing its absorption. In tests made during commercial sulphuring the concentration of gas was found to be in the 1-2% range. The rate of gas production can be controlled to some extent by varying the air supply to the molten burning sulphur. This may prove of special consequence on windy days when the sulphur tends to burn more quickly.

21. Time of Exposure. This variable has a marked influence on the amount of gas absorbed. Absorption, at first rapid, approaches equilibrium gradually, depending upon the concentration of sulphur dioxide in the surrounding atmosphere. The fruit shows a steep gradient in its sulphur dioxide content which decreases from its surface inwards. In Australia a sulphuring time of 5-6 hours which is recommended for apricots to be sun dried, is reduced to 3 hours when the fruit is to be dehydrated. For sun drying pears, an exposure of up to 18 hours is needed.

22. Temperature. Although the absorption by the fruit of sulphur dioxide decreases with increasing temperature, the effect is too small to be of practical significance.

23. Desorption.
(a) Since fruit begins to lose sulphur dioxide as soon as it is removed from the sulphuring enclosure, it should be placed to dry in the sun, or in the dehydrator, as quickly as possible.
(b) Factors affecting the drying rate of fruits will influence markedly the retention of the preservative and it is surmised that it is the sealing of fruit surfaces which limits desorption.

24. Rate of Drying. Low ambient temperatures or high relative humidities during sun drying decrease the rate of drying, so resulting in a poor retention of sulphur dioxide which, under adverse conditions, may be as low as 2-3% . If this occurs the fruit may be re-sulphured within 24 hours of first being put out to dry.

SUN DRYING

25. Since the efficacy of sun drying will depend on climatic conditions, careful consideration is needed of meteorological data relating to the time of crop maturity. A maximum dry bulb temperature of from 80° - 100°F with a relative humidity of below 50% will allow a satisfactory rate of drying.

26. Under good climatic conditions drying times may vary from 2-3 days for apricots, up to 14 days for pears and large peaches. Where a long drying period is involved the fruit trays should be stacked, for much of the latter part, so as to minimize the bleaching of dried surfaces.

DEHYDRATION

27. Dehydration has several advantages. Fruit can be dried irrespective of climatic conditions and the product is cleaner than in the case of sun drying where dust and insects may collect on the sticky surfaces of the drying fruit. The times taken for dehydration are much shorter than for sun drying, being 8-12 hours for apricots, 12-18 hours for peaches, 16-24 hours for apples, and 20-30 hours for pears, prunes and figs.

28. Types of Dehydration. Perry et al[4] have listed the various types of dehydrators suitable for drying fruit. In Australia most of the small and medium sized dryers are of the counter flow tunnel type in which the trolleys of fruit progress in a direction opposite to the air flow so that they enter the cool end and finish at the hot end of the tunnel.

29. Air Velocity and Recirculation.
(a) Air speed in the type of dryer described should range from 500 to 800 linear feet per minute in an empty tunnel. This velocity suffices to provide the heat needed to evaporate moisture from the surfaces of the fruit and also to remove moisture vapour. The air velocity should be kept as uniform as possible to ensure even temperature and drying within the tunnel.
(b) Observation of the dry and wet bulb thermometers at the cool end of the tunnel should determine how much of the air should be recirculated for maximum heat efficiency. The control vents should be adjusted so that the relative humidity at the cool end of the tunnel is maintained at between 50 and 60%.

30. Temperature of Drying. As the fruit enters the cool, humid end of a counter flow tunnel its temperature approaches that of the wet bulb thermometer. As drying proceeds evaporation decreases and by the time the fruit reaches the hot end its temperature approximates that shown by the dry bulb thermometer. The maximum temperature reached should be between 140° and 160°F. It is important that no heat damage should occur to the product during the final stages of drying.

31. Source of Heat. The type of fuel used usually depends on its cost and, as a consequence, on geographical situation. Wood-fired units used initially in Australia have been replaced largely by oil-burners. With oil, a thermostatic control of the inlet temperature enables precise operation, but with wood fuel wide fluctuations are unavoidable.

STORAGE OF DRIED FRUITS

32. Moisture Content. Fruits should be dried to a moisture content inhibiting microbial growth which in practice is usually between 15 and 20% or corresponding to equilibrium relative humidites of 60 to 70%. If the relative humidity is below that range the dried fruit, if kept under open storage, will lose further weight. Where the relative humidity is high for a long period, say averaging 80%, there is a distinct danger of the dried fruit absorbing sufficient moisture to allow microbial spoilage.

33. Packaging. Most dried fruit in Australia is packed initially in paper lined wooden cases holding about 40 lb of fruit. Insect infestation in cased fruit is controlled by the addition of ethyl formate which volatilizes without leaving a residue. The trend in Australia is towards retailing dried fruit, particularly apricots and apples,

in small plastic packs containing about 23% moisture. Fruit from these "moist" packs is easier to reconstitute and cook and when eaten raw is more palatable. The keeping quality of moist packed prunes can be ensured by hot filling or, if the film packaging permits, by heat treatment after sealing.

34. Sulphur Dioxide Level. In the hotter parts of Australia a level of 3000 p.p.m. of sulphur dioxide is necessary in dried fruits for a storage life of up to 12 months.

35. Effect of Temperature. The rate of browning increases as does temperature. For prolonged storage under really hot conditions, holding at temperatures below 68°F is desirable.

USAGE OF DRIED FRUITS

36. Further Processing. Dried fruit is convenient for use in processed foods such as jams, chutneys and various confectionery products as it can be stored at ambient temperature until it is required.

37. Reconstitution for Cooking. Most of the fruit dried in Australia is consumed after cooking. Soaking prior to cooking is necessary and, since individual pieces are fairly large, a soaking period of up to 24 hours may be necessary.

38. Cooking. Following soaking, the fruit should be cooked for 10 to 20 minutes. Much of the sulphur dioxide is driven off during the cooking but about 50-100 p.p.m. remains, detectable only by the few consumers sensitive to such low concentrations.

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